Industrial Hygiene as a Factor in Production

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IT was not always a pleasant duty during the war period to show credentials to a plant manager and to announce the unpopular task of plant inspection. Government inspectors were constantly coming and going until the managers often begged for a respite that they might have time to attend to their work. Occasionally, however, managers welcomed inspectors. At times when the inspectors were specialists in their field, they were eagerly sought. It fell to the lot of the office to which the writer was attached to receive requests to assist plants where either the raw materials, intermediates or finished products constituted a health hazard. The management at such times was puzzled as to how to check high sick rate, absenteeism and decreased production in certain departments. Often, despite strenuous efforts to recruit employees, despite a constant force of new employees being hired and in the face of a persistent demand to increase output, the working force decreased. Impressions received while on such duties have fully confirmed the writer's opinions concerning the close relationship which, under other circumstances, he has observed between safe working conditions and a normal output. It is, among those who have followed scientific production, a demonstrated fact that working conditions have a determinable relationship to output. When these working conditions are insanitary, output diminishes; when they conform to hygienic laws, output approximates its maximum, other things being normal.

Working Conditions Retarding Production

Several records from a mass of data taken from experiences in ordnance and allied plants during the hectic days of the war, when more production and still more production was being demanded, and when all things that stood in the way were relegated to the scrap heap, illustrate this fact. In some instances, plants were so impressed with the results that they continued, as a business proposition, to perfect their working conditions after the armistice.

The abnormal working conditions which retarded production were varied. A few case histories will illustrate these conditions:

Case I

This firm manufactured an abrasive material. The operations of crushers, lathes, conveyors, elevators, and hoppers gave forth large quantities of very fine dust. The work rooms in which these operations took place were always in a dense cloud. Air samples taken with the Palmer Dust Machine showed approximately 213,000,000 dust particles of one-fourth standard units per cubic foot of air. One test, at a particularly bad machine, showed 1,050,000,000 dust particles of the above size having a weight of 23.6 mgs. in each cubic foot of air. The escape of this dust, which was valuable, was a decidedly costly waste chargeable against production. Labor was found to be more than usually unstable. Although some of these processes called for semi-skilled labor, such labor was difficult to obtain and stayed only a short time after employment. There was a history of "coughs, lung-troubles, nose and throat troubles." This physical effect was natural and would be expected when the air dustiness in the work rooms taxed the dust filters of the nose and throat with the removal from a day's air supply of approximately 28,755,000,000 dust particles of one-fourth standard unit size alone, not counting the larger particles;

the one-fourth standard unit size being ten microns and under, or the size found by the South African Commission to be most injurious to the mucous surfaces and to the lungs. Plant records showed, moreover, a high absentee record, while "unemployment within employment" was a source of much lost time. These conditions were not new but were of long standing and had forced attention when the strain of production showed the inability of the workers to stand up under them. By means of specially designed hoods, modifications in the operations of the exhausts, and changes in the fume line, the air dustiness was practically eliminated, thereby conserving abrasive material and improving working conditions.

In many plants similar conditions were met. The improvements installed were financially profitable. One plant conserved daily $100 worth of valuable dust. Another met the cost of installing its improvements out of dust saved within a three month period, in addition to the benefits of removing hazardous dusts from the work places of the employees.

Case II

A new powder plant, handling T. N. T. and Tetryl, employed a large force of women and girls. It was found at first that the women could turn out as much work as men. After a few months the absentee records showed much instability among the women, absenteeism increased, and the plant medical and surgical relief office reported a high sickness rate. Then turnover began to increase. It became noised abroad that the plant was not a healthy place in which to work and the difficulty of getting employees increased. The output of this plant was very essential in keeping up the supply of munitions. The management was puzzled. It had a good medical department and an excellent staff of physicians and nurses and many welfare plans had been instituted for the employees. Cursory investigation showed the girls had discontinued work because of swollen faces, often so badly swollen as to close the eyes. In a trip through the operating departments, employees were found with areas of the face, hands and arms in a highly inflamed condition. It became apparent that certain processes, although seemingly safeguarded, yet emitted quantities of minute particles of T. N. T. and Tetryl. The workers, partly through their own carelessness and partly through inadequate protection, were exposed to and suffering from a powder dermatosis. Indiscrete advice passing from worker to worker, and a failure on the part of the forewoman to carry out the instructions of the medical and surgical relief office, had so magnified the problem as to increase the sick rate, absenteeism, and turnover noted. Such conditions readily yielded to correction and control.

Occupational dermatoses caused by dusts, liquids and fumes are common and almost invariably slow up production. They either give the plant an unsavory reputation and thus increase the difficulty of securing high grade workers or cause painful lesions, as in furunculosis, which retard the output of the worker or cause a sickness absenteeism puzzling and costly to the management.

Case III

This was another powder plant. A new explosive was manufactured. The buildings were well placed and effectively equipped to protect health and life. They were planned and constructed under government supervision and cost. On the same acreage, however, was another plant owned and operated by the firm which made the new explosive. This plant complained of the grade of employees available and of their instability. The medical office recorded a high percentage of poison cases. Cyanotic workers were found in the aniline production house. Men would stay there only a short time. Working conditions were bad. Pools of aniline oil were on the floors, fumes from the tanks came forth whenever the tanks were charged. Exhaust hoods were misplaced, while the air supply ducts were ineffective because of an ineffective fan. Here was an aniline hazard, the seriousness of which was known but precautions against which, despite the numerous cases of poisoning, were not provided.

A typhoid hazard was also present in this plant. The construction camp adjoining used the open privy vault. The commissary with its large kitchen and eating room swarmed with flies from the open vaults. Other hazards were also present. With them went a record of difficulty to get employees greater than that of neighboring plants because of the reputation that had gone forth, sickness in excess, absenteeism turnover, all creating added costs in production and delaying output correspondingly.

The foregoing are typical cases, pertinent here because they illustrate working conditions common to indus-

trial establishments.[1] They indicate cost items, unfortunately not often included among the unnecessary plant wastes on the production cost sheets and hence ordinarily receive scant attention except when legislation is against them.

SANITARY WORKING CONDITIONS VITAL TO PRODUCTION

Manifestly the health, comfort and contentment of the worker are vital factors in production. These contribute to the physical capacity as well as to the mental willingness to produce, that is, muscle power and will power, without which production lags. As there is an intimate relationship between health and hygiene, there is also an intimate relationship between hygiene and production. In so far as production is concerned, what it asks of the worker is that he shall use his brain and muscle in conjunction with the mechanical devices placed at his disposal to render an output equivalent to the wages paid, which wages are based upon cost factors in relation to sales prices so determined as to enable the management to present dividends to the stockholders. In order to meet his share in production, therefore, the worker must be physically fit and, if individual initiativeness is a factor in his labor, he must be mentally alert. In order to be physically fit and mentally alert, he must have had not only training and experience in the particular kind of work assigned to him, but he must also be able so to coördinate his muscle action as to get the full value of each group of muscles for the labor which he has to perform. It becomes essential, therefore, in the interest of full production, that the worker shall be physically and mentally fit for his work. Whatever interferes with such fitness causes a loss in output.

If physical strength is analyzed on the basis of the physiological relationship of the various parts of the body, it will be noted that the available energy of any group of muscles depends upon the healthy functioning of the body; hence, whatever interferes with such normal functioning, such as dust, fumes, gases, excessive heat or cold, plant insanitation, any or all, are a handicap to productive ability. There is a difference in the extent of the handicap, perhaps, dependent upon the power of the body to cope with such causative agency or agencies and the nature of the influencing factor itself. This variant is commonly referred to as body resistance or individual susceptibility; but barring immunity, natural or acquired, the body reacts unfavorably to such causative agencies impairing the health, and productive ability is, therefore, correspondingly reduced.

There is another group of adverse industrial conditions which affect muscular activity. The science of physiology has demonstrated that strain unduly prolonged as well as adverse working conditions permit the accumulation of waste products in the muscles. These products later may be distributed throughout the system. Not only may these accumulated wastes, some of which act as toxins, injure the particular muscles where they originate, but, when distributed by means of the blood stream, may also affect the more vital organs, with the ultimate result that no matter what the incentive may be, the worker is unable to produce a normal output. For example, recent studies in fatigue[2] have shown that in

[1] See *Diseases of Occupational and Vocational Hygiene*, by George M. Kober and William C. Hanson; *Occupational Diseases*, by W. Gilman Thompson, M.D.; *Diseases of Occupation*, by Thomas Oliver; Bulletin 100 of the Bureau of Labor Statistics.

[2] Bulletin No. 106, *Studies in Industrial Physiology:* "Fatigue in Relation to Working Capacity." United States Public Health Service.

certain prolonged occupations production invariably decreases. English studies[3] show that under heavy lifting for prolonged periods, as well as under prolonged strain from long hours of work, muscular efficiency declines to a point where the labor of the workers so affected is a loss to the plant. Exactly the same results follow where workers are obliged to work in strained postures and at occupations where they are required to stand without intermission for long periods, or where they are exposed to inadequate ventilation and inadequate lighting, either too low or too great an intensity or too much glare. Indicative also of the effect of such conditions is the increased accident rate, both in frequency and in severity. Aside from the physical reaction on the nervous system and its effect on the mental attitude of the worker, there is a psychological effect which follows the laws of suggestion and imitation.

As the orderliness of an environment suggests orderliness in personal conduct, and as uncleanliness in surroundings likewise begets uncleanliness in conduct, so air dustiness and uncleanliness suggest slovenliness in the attitude and workmanship of the worker. Moreover, as there is a physical reaction restricting normal breathing in the presence of unpleasant odors, so also there is a tendency to withdraw from unpleasant sights, sounds and conditions causing discomfort. Wherever, therefore, working conditions present unpleasant odors, or distracting sounds, and require contacts with materials that cause personal discomfort, such as extremes in heat and cold, wet processes, foul or filthy liquids, there is a corresponding retardation of activity on the part of the worker. No normal worker ever gets adjusted to unpleasant working conditions to the extent that he is able to produce in their presence as much as he is able to produce when they are absent.

There is a further reaction here. The workers on the job not only slow up in their output, but many refuse also to continue in such employment, making up a large percentage of the turnover in industry. Often there is a tendency to accept such workers as nomads when the fault is not with the worker but with the job which has been assigned to him; that is, he is asked to do tasks not inherently unattractive, but permitted to become so because of the failure of the plant management to recognize the part which psychology plays in stabilizing employment. It is true that industrial establishments, recognizing the undesirability of certain processes or occupations, often furnish inducements in the way of shorter hours or higher pay in order to retain employees at such tasks. Nevertheless, the fact remains that a large percentage of "quits" are due to a dissatisfaction with the conditions under which certain jobs have to be carried on, notwithstanding that the reason assigned by the employment office or foreman may read otherwise. This is a result which corresponds to those other results previously mentioned, where, upon the discovery of the hazardous character of the work engaged in, workers have given up their employment without delay. Furthermore, it should be remembered that occupational health hazards give agitators in industrial establishments arguments to stir up industrial unrest. It is natural that workers should resent unnecessary exposure to hazards injurious to their life or health. Ordinarily, disloyalty to the management is not easily created; only when it can be stimulated by arguments which point out the injustice of the risks to which

[3] *Industrial Efficiency and Fatigue in Munitions Plants*, No. 230, Bureau of Labor Statistics.

the worker is unnecessarily exposed can it be raised to the point where soldiering, sabotage, unreasonable strikes and their like result. Needless to say that where such practices are indulged in materials are wasted, time is thrown away and output suffers. Interruptions to continuous employment, fostered by agitation, are likely to occur where adverse working conditions furnish the talking points.

THE PRICE OF OCCUPATIONAL HEALTH HAZARDS

It is difficult to mass exact figures which show the losses from the foregoing causes. In several articles recently published, the writer has attempted to show that from sickness alone production within the United States is decreased yearly by the withdrawal from active service of practically one million full-time employees out of the forty million employees annually at work. In absenteeism various plants have shown records of days lost per year per thousand employees, varying from seven thousand six hundred and eighty days in plants where absenteeism was fairly low to thirty-one thousand eight hundred and sixty days in plants where the rates were high. This means an annual loss in some instances from full time production of approximately one hundred and six men per every thousand employed. In a similar way turnover has been shown to vary in plants from 40 per cent to 400 per cent annually, while in some departments it has risen to 1,100 per cent. The mere cost of such turnover running from fifteen dollars to three hundred dollars per worker, depending upon the degree of skill required in the process, makes, in a large plant where the rate is high, a measurable deficit from wages and dividends. It will be noted that the emphasis in the foregoing discussion has been placed upon the losses to production through the change or transfer of employees from job to job. Only a mortality table or a life expectancy table for each trade could picture, with any degree of accuracy, the effect upon life itself of occupational health hazards.

It will thus be seen that the price which production pays for occupational health hazards is an undue amount of sickness, abnormal absenteeism, increased turnover, delays in carrying forward work because of such losses, a feeling of uneasiness among employees accompanied by antagonisms and sabotage, and difficulty in getting employees to fill vacancies due to the bad reputation given to the plant by those who quit. More and more plant credit among the big banking houses is being made to depend on the working conditions within the plant and the harmonious relationship between the plant employee and the management. Borrowing capacity is reduced when working conditions are abnormal and industrial unrest is instigated thereby.

The situation in industrial plants today, in so far as safe working conditions are concerned, is not a hopeless one. Indeed the prospects are exceptionally good. The plant manager who seeks to maintain his plant at the highest efficiency has many aids now available which were not very well known a decade ago. The characteristic feature of these aids is that they emphasize the human factor in production. Here science thinks in terms of the human machine. Inventive genius in perfecting mechanical means of production finds limitations in the mental and physical capacity and disposition of the worker to utilize machinery continually and intelligently. These limitations have forced the development of a comprehensive program, scientifically sound, along the lines of labor adminis-

tration including employment management and coöperative production, accident prevention and industrial hygiene. Each is a complement to and supplement of the others. In the field of industrial hygiene there are perhaps a greater number of factors involved, having a scientific basis, than in the other fields, and the investments made therein yield the most permanent results. It is not an easy task, however, to apply the principles of industrial hygiene to the average industrial establishment. Technical and professional training in the management along industrial hygiene lines are essential; without them, time and money are bound to be wasted. Hence, whenever a program of industrial hygiene is to be inaugurated a specialist should be attached to the management force, to plan and direct it, if the plant is large enough to use his full-time service, or if the plant is small, a consulting service should be utilized. Irrespective, however, of the mode of supervision adopted, there are certain points which must be borne in mind in order to secure efficient planning and administration. These may be summed up as follows:

SANITARY EQUIPMENT OF INDUSTRIAL PLANTS

Each plant in industries of dissimilar character has an individual problem. Even where plants are similar, there is sufficient variation to make a "ready-made" plan unwise. The "ready-made" program may be mischievous. Much depends upon the type of building occupied, its location, area and the accessibility of public service facilities. It is highly desirable, prior to the construction of the plant and even prior to the occupancy of the building already constructed, to analyze the sanitary equipment with reference to compliance with hygienic laws. Such factors as light and ventilation, natural and artificial, fundamentally important as they are now known to be in the maintenance of safe working conditions, need to be considered in relation to the grade of work which it is proposed to carry on. In like manner, other phases of sanitation, such as water supply, washing facilities, lockers, toilets and, under certain conditions, shower-baths, should be predetermined and placement of workers should be made on the basis of their adequacy and convenience. If buildings are already erected and occupied these factors still call for consideration and standardization. They comprise what is generally understood as the sanitary equipment of industrial plants.

However, a knowledge of plant working conditions and of their effects can be fully determined only by an analysis of the deviations made from other hygienic requirements. Such deviations can best be determined by both a process analysis and a job analysis. In such process analysis the various steps in manufacturing from raw material to the finished product need to be outlined, including the nature of the substance, the conditions under which they are used, the intermediates that are formed and the wastes that are eliminated. Such a process analysis reveals the known occupational poison hazards, and suggests ways whereby they may be removed.

The chief duty, however, of the industrial hygienist is not simply to eliminate hazards. The positive aspects of plant hygiene come more particularly through the job analysis which aids in the placement of employees in occupations and at tasks for which they are fitted by training, experience and by physical ability. Such job analysis determines the working requirements for each job and simplifies the place-

ment of workers so as to facilitate production with the least possible strain and injury to the workers thus scientifically placed.

Fitting the worker to the job requires a knowledge of what are the best age groups, heights and weights for such job, as well as what is needed of the worker by way of accuracy of vision and of hearing, keenness of mentality, temperamentality, ability to stand fatigue or to meet muscular strain. Job analysis determines the excess motions that may be eliminated as well as the rest periods essential in order that fatiguing stretches of work may be broken and the waste products created in the muscles of the worker be carried off.

It is apparent that this phase of the industrial hygiene program requires close coöperation with the medical and surgical relief department in the physical examination of workers as a basis of selection and transfer for particular jobs.

The foregoing program meets most of the problems having an effect upon the productive capacity of the worker that arise from within the plant. However, industry is constantly bringing forth new materials that are relatively harmless taken separately, but that are injurious to health in their combinations. In order that the effect of such new hazards may be discovered, it is advisable that careful plant records be kept which will tell the amount of sickness, accidents, absenteeism, turnover, output, attendance on relief rooms, nature of illness and similar information upon the basis of which a current index of plant conditions may be made. These records analyzed by occupations, processes and departments and eliminating the possible causative factors not arising from plant insanitation, will give the probable responsibility of such insanitation for such extraordinary costs in production.

By the foregoing methods, modified as conditions may require, industrial plants may increase their productive capacity without jeopardizing the health of the worker or interfering with his personal rights and in a way financially profitable to both.